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Life and Microgravity Sciences and Applications

Using the Space Environment to Improve Life on Earth

NASA's Office of Life and Microgravity Sciences and Applications (OLMSA) seeks to advance scientific knowledge, enable the development of space for human enterprise, facilitate the development of commercial space products, and transfer the resulting knowledge and technologies as broadly as possible.

OLMSA's programs include research in the life and microgravity sciences, commercial research, and space medicine research. OLMSA research is selected through open and competitive processes and includes a balance of ground-based and flight research. Flight research platforms have included the Space Shuttle, unpiloted vehicles, and the Russian Mir space station. The International Space Station will provide OLMSA with a quantum leap in flight research capability.

Life Sciences Programs

OLMSA's life sciences research investigates the role of gravity in shaping living systems. The resulting knowledge is used to ensure the health and safety of space crews and to improve the health and the quality of life of people on Earth.

- **Gravitational Biology and Ecology—**Researchers study gravity's influence on the evolution, development, growth, and internal processes of plants and animals. Their results expand fundamental knowledge that will benefit medicine, agriculture, and other industries.

- **Biomedical Research and Countermeasures—**Researchers seek to understand and control the effects of the space environment on space travelers (e.g., muscle atrophy, bone loss, and fluid shifts).

- **Advanced Human Support Technology—**Researchers develop technologies, systems, and procedures to enable safe and efficient human exploration and development of space.

Microgravity Research

NASA's Microgravity Research program reveals important physical, chemical, and biological processes that are obscured by gravity on Earth. Frequently, the research allows scientists to provide superior measurements of fundamental physical and biological properties unattainable on Earth. This data can be used to validate or challenge scientific theories, or serve as the basis for developing new theories to explain unexpected discoveries. For many scientific disciplines, research in the space environment is a new realm of discovery, providing fundamental insights that can serve as the basis for new applications and technology.

- **Biotechnology—**Microgravity allows researchers to produce protein crystals for drug development and to grow three-dimensional tissues for research.

- **Combustion Science—**Scientists use low gravity to simplify the study of complex combustion (burning) processes. Because combustion is used to produce 85 percent of Earth's energy, even small improvements in efficiency will have large environmental and economic benefits.

- **Fluid Physics—**The behavior of fluids is profoundly influenced by gravity. Researchers use gravity as an experimental variable to explain and model fluid behavior in systems on Earth and in space.

- **Fundamental Physics—**Scientists use low gravity to test fundamental theories of physics with degrees of accuracy that far exceed the capacity of Earthbound science.

- **Materials Science—**Researchers use low gravity to advance our understanding of the relationships among the structure, processing, and properties of materials.

Space Product Development

The Space Product Development program facilitates the use of space for developing commercial products and services, couples NASA and private sector technology development to the advantage of both, and promotes an awareness of space as a viable research environment for commercial development initiatives. The program facilitates industry's access to space, provides research expertise and flight hardware, and supports the development of policies that encourage the commercial use of space. The core program consists of a series of Commercial Space Centers (CSC's) around the country, which bring together universities and industry affiliates as partners in commercial research primarily using the space environment. The current commercial research can be summarized in these categories: materials, biotechnology, agriculture, food technology, and medical informatics.

- **Materials Research—**The unique microgravity and vacuum properties of space may enable the development of new materials ranging from polymers to semiconductors.

- **Biotechnology—**Products derived from the microgravity environment may include protein crystals for structure-based drug design, new cell separation technologies, and medical encapsulation methods.

- **Agriculture—**Agriculture products derived from the microgravity environment may include new drugs from plants, data leading to improved crops, and enhanced understanding of the plant fragrance formation.

- **Food Technology—**The food technology effort will be dual-use technology development between the Government and the private sector, with benefits derived by both sectors.

- **Medical Informatics—**The medical informatics area includes telemedicine, medical data, and sensors. Spinoff benefits could include items such as devices for remote diagnosis and medical application on Earth.

Space Medicine Research

OLMSA's Space Medicine Research function is focused on ensuring crew health in all aspects of the human space flight program. Through the development of appropriate requirements for medical operations and medical research, Space Medicine supports several activities, including operational monitoring of crew members' health status, the development of longitudinal studies of astronaut health, the development and application of telemedicine, and the development of new technologies for health care.

Some Recent Highlights of OLMSA Research
Radiation Protection

New knowledge was obtained on materials that can protect against the harmful effects of radiation to Space Shuttle crew members. Polyethylene was proven to be a better radiation shield material than aluminum by a factor of two.

Gene Expression

A gene array analysis of human kidney cells exposed to microgravity on STS-90 provided the first comprehensive data of its effects on gene expression. More than 15 percent (1,600 of 10,000) of genes studied changed their expression levels, supporting the hypothesis that there is an identifiable group of gravity-dependent genes. NASA is developing nanotechnologies such as "DNA chips" to allow researchers to probe into the functioning of genes in the space environment. Gaining an understanding of how basic cellular mechanisms are affected by gravity is essential for developing safe technologies and protecting the health of astronauts on long-duration space missions.

- **E-Nose—**Crew Safety was enhanced by the successful testing of the electronic nose, or E-Nose, for early detection of contaminants aboard spacecraft. This new miniature environmental monitoring instrument detects and identifies in real time, a wide range of organic and inorganic molecules down to the parts per million level. The E-nose will contribute to crew safety when its use becomes operational.

- **Medical Imaging**—Two cameras originally designed to help analyze the dynamics of combustion in space showed medical applications. The cameras can pull weak images from strong backgrounds to differentiate tumors from surrounding tissue.

- **Optical Detector**—One of NASA's Commercial Space Centers developed an optical detector. The detector is a thin film designed to be implanted on the back of the retina to generate a local electric current that excites the optical nerves resulting in a signal that the brain can interpret as light. Preliminary testing for biocompatibility has been successful. Therefore this detector could be used for a variety of eye problems.

- **Three-Dimensional Beating Heart Tissue Created**—The NASA bioreactor has successfully engineered heart tissue that could eventually be used to repair damaged heart tissue inside the body, test new drugs on heart diseases, and study general heart development and function.

- **Colon Cancer Tumors Created**—The NASA bioreactor has successfully grown colon cancer tumors similar to those found in humans. As models, the medical community can

use these to study how cancerous tissues form and spread. This research forms the basis for developing strategies for cancer prevention and treatment.

- **Diabetes Complications Treatment—**Researchers on STS-95 flew human insulin crystals bound to a drug that improves insulin therapeutic effectiveness. For the first time, scientists understood the nature of this insulin drug bond and the resultant effect of time-release properties. This research may lead to improvements in treatment that could prevent diabetes-related complications, such as blindness and vascular disease.

- **Composite Granular Material Influences Building Engineering—**Measurements on a composite granular material in the microgravity environment of space has increased the understanding of soil mechanics during major motions. Research on the phenomenon of liquefaction of soil materials during earthquakes may result in safer, less expensive structural foundation engineeering.

Future Initiatives

NASA is currently evaluating options for and benefits of integrating facilities and capabilities where astronauts, medical professionals, scientists, engineers, and operational specialists can interact as a team in a bioastronautics initiative. The National Space Biomedical Research Institute, a critical element of this initiative, will utilize a consortium of 12 U.S. medical research academic institutions, led by Baylor College of Medicine, to use the knowledge gained by working with NASA to improve health maintenance and care for patients on Earth. This initiative will accelerate research and development of solutions for diagnosis, therapy, prevention, and rehabilitation of NASA crew members during long-duration missions and after return.

OLMSA has embarked on a program to develop advanced technologies critical for long-duration space flight. Future endeavors will include: (1) extending the capabilities of human interactions with machines through enhanced sensor, computational, and data-handling capabilities, and (2) use of new biological materials and structural concepts inspired by biological functions found in nature. These fields of research have great potential for application to health care issues here on Earth. The NASA Administrator has established formal collaboration with the National Cancer Institute (NCI) in the area of biologically inspired technology. This initiative will begin in 2001 and be led by the NASA Chief Scientist.

In Fiscal Year 2001, OLMSA will have the opportunity to take advantage of the research capability available after the deployment of the Destiny Laboratory to the International Space Station. Early research will focus on identifying and improving the spacecraft environment, habitability, and crew health. To help maintain NASA's research communities while construction is continuing on the International Space Station, NASA plans to fly a research mission in early FY 2001 and to use increased Shuttle middeck locker opportunities during Shuttle assembly flights.